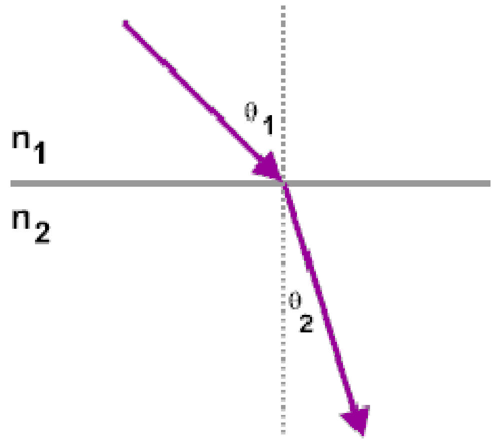
Refraction Index Work

To determine the degree to which a light ray bends as it obliquely transitions from one medium to another, we will use our knowledge of refraction and Snell's Law. For those interested in seeing a derivation of Snell's Law, please reference this accompanying lesson.



$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

where

- n_1 is the index of refraction for the first medium
- n_2 is the index of refraction for the second medium
- that angles θ_1 and θ_2 are always measured from the normal, NEVER from the interface.

Here is a list of common indices for the 589 nm wavelength in sodium's spectrum.

medium	index	medium	index
vacuum	1.00000	fused quartz	1.46
air (STP)	1.00029	crown glass	1.52
water (20ºC)	1.33	polystyrene	1.55
acetone	1.36	carbon disulfide	1.63
ethyl alcohol	1.36	flint glass (heavy)	1.65
sugar solution (30%)	1.38	sapphire	1.77
sugar solution (80%)	1.49	diamond	2.42

If $n_2 > n_1$, then the light is entering an optically more dense medium and the ray will bend "towards the normal" as it enters n_2.

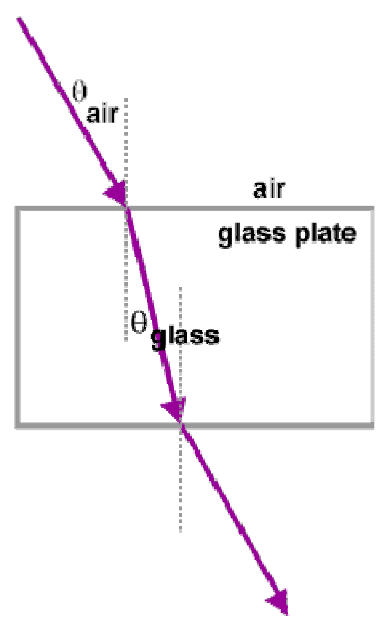
This phenomena occurs because the wavelength shortens in the second medium resulting in the light having a slower average velocity.

Note that the ray bends towards the normal as the light enters the glass and that θ_{glass} is smaller than θ_{air}.

If $n_2 < n_1$, then the light is entering an optically less dense medium and the ray bends "away from the normal" when it enters n_2.

This phenomena occurs because the wavelength lengthens in the second medium resulting in the light having a faster average velocity.

Note that the ray bends away from the normal as the light exits the glass as it returns into the air and that θ_{air} is greater than θ_{glass}.

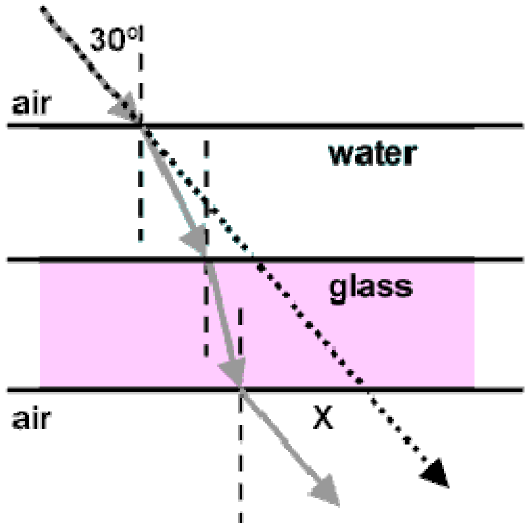


Refer to the following information for the next question.

If a ray of light strikes the top surface of a dish of water at an angle of 37º to the vertical, at what angle will it be refracted as it enters the water?

Refer to the following information for the next six questions.

Suppose a ray of light enters a glass slab (n = 1.56) that is covered with water (n = 1.33) as shown in the diagram below. Each layer is 10 mm thick and the initial angle of incidence equals 30º. Our goal in the following series of questions is to determine the beam's linear displacement, X, from its initial straight-line path when it emerges from the bottom of the glass.



1. At what angle does the ray enter the water?

2. What is the value for x_1 in the diagram shown in the hint?

3. At what angle does the ray enter the glass?

4. What is the value for x_2 in the diagram shown in the hint?

5. What is the value for x_3 in the diagram shown in the hint?

6. What is the value for X?

Lab: Snell's Law : Index of Refraction for Glass

Purpose: To use ray sightings to calculate the index of refraction of glass.
Using your protractor, measure all four angles: the angle of incidence and the angle of refraction at the top interface and the angle of incidence and the angle of refraction at the bottom interface. Label your diagram and then place your answers in the data table provided. Next use **Snell's Law** to calculate the experimental index of refraction for glass based on the angle data for each interface.

$n_{glass} \sin(\theta_{glass}) = n_{air} \sin(\theta_{air})$

since $n_{air} = 1.0$

$n_{glass} = \sin(\theta_{air})/\sin(\theta_{glass})$

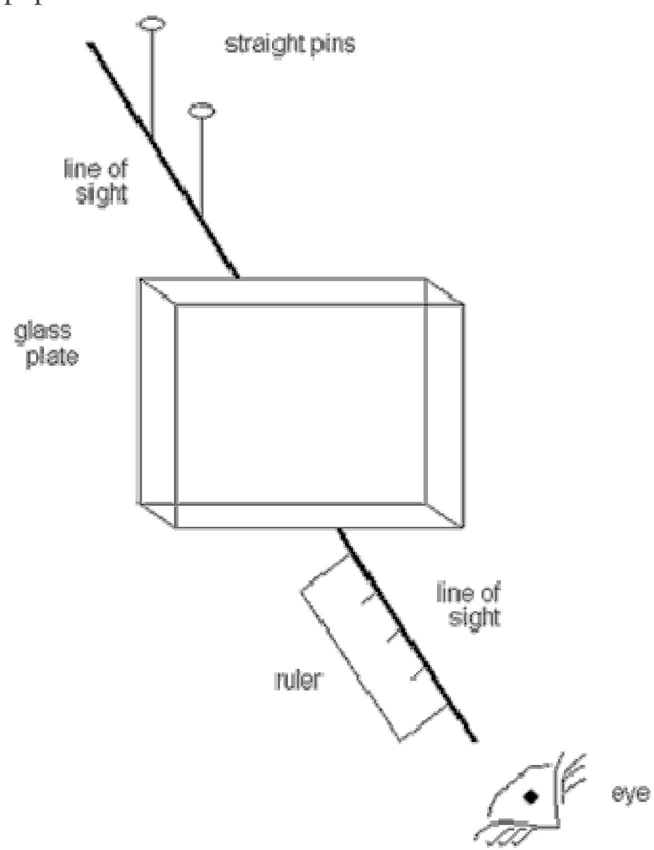
Equipment:

- 7 cm x 7 cm glass square
- ruler
- cardboard
- protractor
- yellow data paper
- 2 straight pins

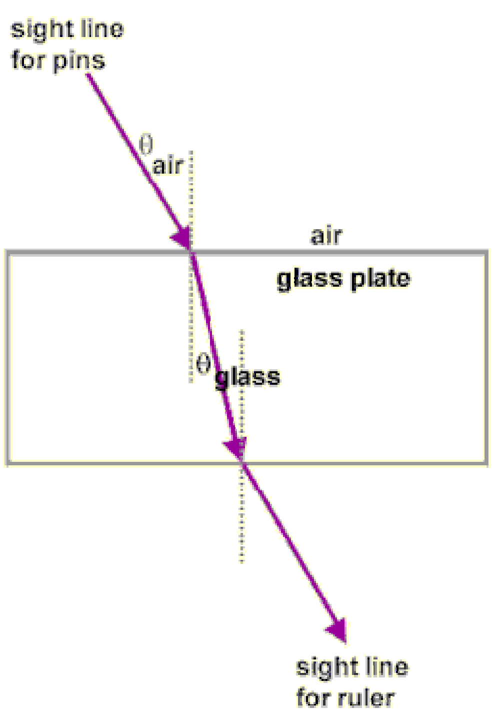
Procedure:

Place the yellow paper on the cardboard.

1. Place the glass plate in the center of the yellow paper and trace its outline in pencil.
2. Place the straight pins into the paper along a slanted line between 2 to 5 cm from the top of the glass.
3. Sight the base of the pins through the glass until the edge of the ruler "appears" to line up with the pins.
4. Using a ruler, sketch this line on your paper.
5. Remove the glass and connect this sight line to the lower edge of the glass outline.
6. Next draw the line that connects the two straight lines to the top edge of the glass outline.
7. Connect the point where the line from the pins on the top edge of the glass outline to the point where the line draw along the edge of the ruler hits the bottom of the glass outline.



Measurements:



Data Table

	top interface	bottom interface
air		
glass		
experimental index		

Measure in cm the length of the path followed by the light through the glass plate. ______________________

Analysis and Conclusions

1. What is the average of your two experimental values for the index of refraction of glass?

2. What was the percent difference (error) between your two experimental values for the index of glass?

3. Calculate the average speed of light (in m/sec) through glass using your average experimental index of refraction.

4. Calculate the time required for the light to pass through the glass plate

5. On your papers, in addition to labeling your angles, color the ray from the pins in color #1 and the normal and glass plate in color #2. Remember to place arrows on each ray showing that the light originated at each pin and traveled through the glass to your eye.